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Soviet Long-Range Energy Forecasts

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SOVIET LONG-RANGE ENERGY FORECASTS

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Foreword

An attempt is made in this publication to reconstruct the thinking of Soviet authorities on long-range development of the USSR's energy position. It is not an independent assessment of the probable actual course of such development. The 15-year period covered – 1976-90 – is too long for making estimates with any real hope for accuracy. The report does, however, point out areas in which the Soviets may encounter serious problems and difficulties in achieving their still tentative goals.

No official Soviet plans for the energy balance beyond 1975 have been released. The most solid evidence of official views is indirect. Soviet energy experts have made some long-range forecasts of requirements and supply that were intended as recommendations to the organization charged with drafting official plans, the State Planning Committee (Gosplan) of the USSR Council of Ministers. In March 1971, for example, N.V. Mel'nikov, an energy expert in the USSR Academy of Sciences, reported that a forecast of the fuel and energy balance of the USSR through the year 2000 had been prepared by the Academy of Sciences and the State Committee on Science and Technology of the USSR Council of Ministers, with the participation of various ministries and departments in the government.* In 1972 or 1973 the Academy of Sciences helped to prepare a "refined" forecast of the energy balance through 1990. This balance presumably served as a basis for formulation of an official plan for 1976-80.**

The general content of these forecasts can be deduced from piecemeal data released in articles by Mel'nikov and others, some as recently as late 1974. They may not, of course, reflect precisely the current thinking of the top economic planners in the USSR, but they probably illuminate their basic objectives. A more current indication of the official energy policy should appear when the Soviet government releases data relating to the Tenth Five-Year Plan (1976-80) and the Long-Range Plan (1976-90) – perhaps in the first half of 1976.

* *Sotsialisticheskaya industriya*, 24 Mar 71, p. 2.

** N.V. Mel'nikov, *Vestnik Akademii Nauk SSSR*, No. 2, Feb 74, p. 75.

SOVIET LONG-RANGE ENERGY FORECASTS

SUMMARY

1. Long-range forecasts of the USSR's fuel and energy balance made by Soviet technicians suggest that the authorities hope to satisfy almost all Soviet needs from domestic production while providing a growing surplus for export, as indicated by the following tabulation:

	Million Metric Tons of Standard Coal Equivalent ¹	
	1973 (Actual)	1990 (Forecast)
Requirements, total	1,520	3,500
Domestic consumption and additions to stocks	1,316	2,960
Exports	204	540
Supply, total	1,520	3,500
Production	1,476	3,400
Imports	44	100
Net exports ²	160	440

1. Standard coal equivalent is defined as having a heat value of 7,000 kilocalories per kilogram, equal to that of good-quality bituminous coal.

2. Equivalent to 2.2 million barrels per day (b/d) of oil in 1973 and about 6.2 million b/d in 1990.

Achievement of these objectives will depend heavily on success in large-scale development of energy resources and on major improvements in technology. In any case, the role of the Soviet Union in the world energy market will continue to be a minor one. Given the serious problems associated with locating and exploiting reserves in remote and inhospitable regions, the USSR will experience great difficulty in achieving the projected levels of production. If production increases less than is projected by the Soviet forecasts, adjustment probably would be by slower growth in consumption and exports, rather than by any massive increase in imports.

2. The forecasts imply a rate of growth in energy consumption of 4.9% per year, slightly less than the 5.2% average rate of growth that prevailed during 1961-73. In the projections, exports increase about 6% per year, substantially less

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than the average growth rate of about 10% per year in 1961-73, but approximately the same as in 1971-73. Crude oil and petroleum products continue to account for most Soviet exports of fuel, although their share declines because natural gas exports increase much more rapidly than exports of other fuels. A growing share of Soviet fuel exports has been going to other Communist countries (about three-fifths in 1974, compared with about one-half in 1960), and this trend probably will continue. The forecasts did not foresee the abrupt rise in oil prices in 1973-74, however, so they undoubtedly undervalue the opportunity cost of selling oil and gas to Eastern Europe rather than to the West.

3. The forecasts call for expanded production of all types of energy – oil, natural gas, and coal, as well as hydroelectric and nuclear electric power. In the forecasts, natural gas accounts for the largest share of the increase. Percentage contributions of various energy sources to total energy production in 1975 and 1990 are as follows:

	Percent	
	1975	1990
Total	100	100
Oil	43	32
Natural gas	21	32
Coal and other solid fuels	33	28
Hydroelectric power	1	1
Nuclear electric power	Negl.	5
Other sources	2	2

The decline that has been taking place since 1960 in coal's share in total fuel production is to come to a halt in the next few years. During the 1980s, coal production is expected to grow faster than crude oil output but less rapidly than natural gas production.

4. The forecasts of energy requirements and supply provide for continued heavy reliance on coal, in part because of uncertainty about future discovery and development of oil and gas reserves. A number of large new coal-fired powerplants are to be built, and output from both old and new coal basins is to be pushed. Since the forecasts were made, the increased price of oil on the world market has increased the incentive to use coal rather than oil where feasible, especially in electric powerplants. Nevertheless, the Soviet authorities have not given any indication that they will convert any of the existing oil-fired powerplants to the use of coal.

5. Four-fifths of the growth in energy production through 1990 is expected to come from Siberia. In the European part of the USSR, the cost of producing coal is extremely high, and reserves of oil and gas will not support further increases in output. As energy consumption will continue to be concentrated in the European part of the USSR and in the Urals, the transport of energy from the eastern to the western regions of the USSR is to increase steadily from the estimated 1975 total of 350 million metric tons of standard coal equivalent (SCE) to more than 1 billion tons in 1990.

6. The USSR apparently intends to rely on Western countries for substantial amounts of materials, equipment, and technology to speed up the exploitation of its Siberian and offshore oil and gas reserves. Long-term agreements with Western firms that provide for repayment in fuels or other commodities are being used to obtain some of this assistance. The USSR will also obtain assistance from its East European partners in the Council for Mutual Economic Assistance (CEMA).¹

7. Even with substantial amounts of foreign assistance, the production forecasts appear optimistic, particularly those for oil, gas, and nuclear power. Achievement of the 1990 oil target (about 1,100 million tons of SCE, or 750 to 800 million tons of oil) hinges on the discovery of new oilfields in the eastern regions of the country. If the production forecast proves to be unattainable, oil exports – which appear to be projected at about 4.6 million barrels per day (b/d) in 1990 – would be endangered. To compensate, Soviet planners could substitute coal for oil in some applications. In addition, the Soviet economy may not grow as fast as forecasts of consumption assume, for reasons quite apart from problems of fuel supply. The USSR might also be able to obtain larger quantities of oil from Middle Eastern countries – probably under barter agreements – than the some 700,000 b/d suggested by Soviet forecasts of total energy imports.

DISCUSSION

Evidence on Planned Energy Requirements

8. Soviet technicians expect that the USSR's energy requirements (domestic consumption plus exports) will grow at a slightly lower rate than in the past. In June 1973, one of Mel'nikov's colleagues in the USSR Academy of Sciences, M.A. Styrikovich, estimated 1990 requirements at 3-1/2 billion tons of SCE, equivalent to an annual growth rate of 5.0% between 1973 and 1990.² Anticipated

1. Bulgaria, Czechoslovakia, East Germany, Hungary, Poland, and Romania.

2. *Kazakhstanskaya pravda*, 10 Jun 73, p. 4 (US Joint Publications Research Service, JPRS 59533, 17 Jul 73, p. 11).

requirements in 1990 presumably include exports because the 1970 requirements figure cited by Styrikovich included exports. During 1961-73, total energy requirements increased at an average annual rate of 5.7%. Subsequent references in the Soviet press to energy requirements for 1990 have been consistent with Styrikovich's estimate, although none has been as specific.

9. A breakdown of requirements for energy in 1990 was given in a Soviet paper presented by the Minister of Power and Electrification, P.S. Neporozhny, at the World Energy Conference in September 1974. The combination of Styrikovich's projection of total requirements and Neporozhny's projection of energy allocations is shown in Table 1. The average annual rate of growth in total

Table 1

USSR: Energy Requirements

	1973		1990		Average Annual Rate of Growth 1974-90 (Percent)
	Percent	Million Metric Tons of Standard Coal Equivalent ¹	Percent ²	Million Metric Tons of Standard Coal Equivalent	
Total requirements	100	1,520	100	3,500	
Consumption		1,314		2,950	4.9
Generation of electricity	16	247	23	805	7
Generation of steam and hot water ³	17	264	24	840	7
Industrial furnaces and related uses	18	273	11	385	2
Mobile and station- ary engines	14	219	13	455	4
Small heating devices	13	203	5	175	-1
Non-energy uses	5	77		225 ⁴	7
Losses	2	31		65 ⁴	
Exports ⁵	13	204	24	540 ⁶	6
Additions to stocks	Negl.	2		10 ⁴	

1. *Narodnoye khozyaystvo SSSR v 1973*, Moscow, 1974, p. 62. The breakdown of consumption is partially estimated.

2. P.S.Neporozhny, *Fuel-and-Power Economy of the Soviet Union at the Current Stage and the Problems in Its Development*, Preprints of Papers Presented at the Ninth World Energy Conference, Detroit, Sep 74, vol. 1, no. 1.2-4, p. 11.

3. Including steam and hot water from thermal powerplants and large boilers.

4. Estimated.

5. Excluding exports of electricity, which for the most part is not primary energy and presumably is included under consumption.

6. Residual.

consumption of 4.9% in 1974-90 is slightly less than the 5.2% rate that prevailed during 1961-73. In 1961-73 the growth in energy consumption was about equal to the growth in GNP, which averaged 5.5% per year.³ Relatively high rates of growth are implied for energy used in electric power production and for non-energy uses, such as in chemical processing. A relatively low rate of increase is forecast for fuel used in industrial furnaces, the largest element of which is coking coal for the steel industry. The forecasts by Styrikovich and Neporozhny call for a relatively high rate of growth of energy supplied for centralized generation of steam and hot water. A substantial share of this growth is intended to reduce the need for small, less efficient heating units – for example, furnaces for individual apartment houses. A more-or-less average growth rate is projected for fuel to power mobile and stationary engines.

Implications for Fuel Exports

10. The growth of energy exports (a residual calculation) is about 6% per year – substantially less than the average growth rate of about 10% per year in 1961-73, but approximately the same as the rate in 1971-73. In 1974 the rate of growth was only about 4% because exports of oil to non-Communist areas declined by about 10%, or 7 million tons of SCE.⁴ Nonetheless, oil will continue to account for the bulk of fuel exports, although its share will decline somewhat because of a rapid rise in exports of natural gas. Long-term agreements concluded with East European countries provide for natural gas exports of 32 to 35 billion cubic meters per year, and agreements with West European countries for another 24 billion cubic meters per year. Additional contracts probably will be signed that would boost exports to Eastern Europe to 72 billion cubic meters per year by 1990 and exports to Western Europe to 30 billion cubic meters per year. Negotiations have also been conducted with Japan and the United States on contracts totaling 40 billion cubic meters per year.

11. If these numbers are reflected in Soviet forecasts of energy requirements in 1990, the forecasts provide for natural gas exports of about 142 billion cubic meters (170 million tons of SCE). If it is further assumed that the forecast for

3. For further discussion of energy consumption and GNP, see the Appendix.

4. Derived from data in *Vneshnyaya Torgovlya SSSR za 1974 god*, Moscow, 1975. Exports of crude oil and petroleum products totaled about 166 million tons of SCE in 1974, 78% of total fuel exports and about 5% of world exports of crude oil and petroleum products. Soviet earnings of hard currency from sales of oil doubled, although the quantity exported to hard currency areas declined by about 13%. Prices of oil exported to other Communist countries changed very little in 1974, but will more than double in 1975. Thereafter, they are to rise gradually to the world market level, which in January 1975 was four to five times the January 1973 level.

coal exports provides for a moderate increase from the 1973 level of 25 million tons to about 40 million tons⁵ in 1990, the projected export of crude oil and petroleum products in 1990 falls out as a residual - 330 million tons of SCE, or 4.6 million b/d.

12. In 1974, 62% of the exports of oil and petroleum products went to other Communist countries, about 27% to hard currency areas of the non-Communist world, and the remainder to soft currency areas. Minister of the Petroleum Industry Valentin Shashin declared in 1974 that the USSR would continue to meet "almost fully" the petroleum requirements of other Communist countries.⁶ The needs of these countries, however, may well rise faster than projected Soviet exports. In addition, a substantial share of projected exports probably is earmarked for export to non-Communist countries to earn hard currency. In this connection, Shashin said the USSR would continue to deliver oil to capitalist countries in quantities provided for by "special agreements."

13. Shashin may have been referring to long-term agreements that would provide for deliveries of oil in exchange for developmental credits. The USSR and Japan signed an agreement in December 1974 providing Japanese credits for exploration for oil offshore from Sakhalin Island.⁷ If enough oil is found, Japan will receive possibly as much as 25 million tons per year. Japan has lost interest in an earlier proposal to supply credits for construction of a Siberian railway in return for 25 million tons of oil per year. The USSR has also discussed with US firms the possibility of help with secondary and tertiary recovery of oil in older oil-producing areas of the USSR, again with repayment in oil.

Evidence on Planned Supply of Energy

14. The paper presented by Neporozhny to the 1974 World Energy Conference did not reveal the sources of energy supplies in 1990, although it did state that the share of coal in the total fuel supply would not decline further after 1980. Other information has appeared in the Soviet press on the future energy supply balance, however:

- Mel'nikov published a percentage breakdown for 1990 in 1971.⁸

5. Coal exports will rise by 6 to 7 million tons per year as a result of a long-term agreement with Japan to share in the exploitation of coal reserves in the Yakutsk ASSR. *Japan Economic Journal*, 2 Jul 74, p. 4.

6. V. Shashin, *New Times*, no. 15, Apr 74, p. 21.

7. Foreign Broadcast Information Service, *Daily Report, Soviet Union*, 11 Dec 74, p. M-1.

8. N.V. Mel'nikov, *Toplivno-energeticheskiye Resursy SSSR*, Moscow 1971, p. 7.

- L.A. Melent'yev, another energy expert in the USSR Academy of Sciences, gave absolute estimates for crude oil, natural gas, coal, and nuclear energy in a 1974 article discussing alternative energy supply policies during the next "10-15 years."⁹

The USSR's projected energy supply in 1990 as derived from these Soviet sources is shown in Table 2.

Table 2

USSR: Requirements for and Supply of Energy

	Million Metric Tons of Standard Coal Equivalent						
	Actual ¹			Estimated		Forecast	
	1960	1970	1973	1974	1975	1980	1990
Total requirements	742	1,289	1,520	1,592	1,680	2,150²	3,500
Consumption	678	1,119	1,314	1,375	1,450	1,840 ²	2,950
Exports	60	167	204	212	225	300 ²	540
Addition to stocks	4	3	2	5	5	10	10
Total supply	742	1,289	1,520	1,592	1,680	2,150	3,500
Production of fuel	692	1,223	1,421	1,503	1,585	1,980	3,140
Gas	54	234	282	313	340	500	1,100
Oil ³	211	503	614	656	700	860	1,100
Coal	373	433	469	479	490	560	870
Peat, shale, and fuelwood ⁴	54	53	56	55	55	60	70
Hydroelectric power ⁵	6	15	15	16	17	20	35
Nuclear electric power ⁶	Negl.	1	4	6	7	40	175
Other sources ⁷	33	36	36	36	36	40	50
Imports	11	14	44	31	35	70	100
Net exports	49	153	160	181	190	230	440

1. *Narodnoye khozyaystvo SSSR v 1972*, Moscow, 1973, p. 70. *Ibid.*, v 1973, Moscow, 1974, p. 62.

2. Interpolated.

3. Including gas condensate.

4. Excluding fuelwood gathered by the population, which might amount to as much as 30 million tons of standard coal equivalent per year.

5. Converted at the rate of 123 grams of standard coal equivalent per kilowatt-hour (the heat value of electricity), which corresponds to Soviet practice. If hydroelectric power were converted at a rate corresponding to the average amount of fuel required to produce electricity in thermal powerplants, which is the practice in some countries, the figures for hydropower would be approximately tripled.

6. Nuclear electricity is not shown explicitly in Soviet statistics on fuel-energy balances and does not appear to be included in "other sources" because the total shown for other sources has remained virtually unchanged since 1965. Estimated values have therefore been added for nuclear electricity at a rate of 350 grams of standard coal equivalent per kilowatt-hour through 1975, 325 grams in 1980, and 300 grams in 1990. This conforms to the practice of the Organization for Economic Cooperation and Development, and apparently to the practice of at least some Soviet energy technicians.

7. Minor sources of primary energy, such as agricultural wastes, together with secondary sources such as coke oven and blast furnace gases.

9. L.A. Melent'yev, *Izvestiya Akademii Nauk SSSR, Energetika i Transport*, May-Jun 74, p. 16.

15. Four-fifths of the increment in energy production forecast through 1990 will come from Siberia.¹⁰ Because energy consumers will continue to be concentrated in the European part of the USSR and in the Urals, increasing quantities of fuel will have to be shipped from the eastern to the western regions of the country.¹¹ In 1975, shipments from east to west will total an estimated 350 million tons of SCE; by 1990, shipments of fuels and transmission of electric power are expected to exceed 1 billion tons of SCE.¹²

Natural Gas

16. The Mel'nikov and Melent'yev projections indicate that production of natural gas is to increase from about 261 billion cubic meters in 1974 (313 million tons of SCE) to about 900 billion cubic meters (1,100 million tons of SCE) in 1990, or about 8% per year. In this formulation, gas would account for approximately two-fifths of the growth in energy supplies in 1976-90. Soviet planners were slow to appreciate the potential of natural gas, and, despite the existence of large reserves, development of the gas industry did not begin in earnest until the late 1950s. This development has been plagued by problems, notably by lagging installation of gas distribution systems and consuming equipment.

17. Total estimated natural gas reserves (excluding gas associated with crude oil) are roughly 100 trillion cubic meters (120 billion tons of SCE).¹³ Twenty-three trillion cubic meters were in the A+B+C₁ categories of explored reserves as of January 1974.¹⁴ Soviet pronouncements about gas reserves normally do not state what portion of these are considered to be economically exploitable, but a Soviet geologist indicated that this was true of all of the reserves reported to be in categories A+B+C₁ as of January 1971 (16 trillion cubic meters).¹⁵ If an extraction rate of 80% is assumed, recoverable reserves as of January 1974 (18 trillion cubic meters) were twice as much as the amount of natural gas (including associated gas) scheduled to be produced during 1974-90 (about 9 trillion cubic meters, according to the projections in Table 2). If output were to increase as indicated, and if the ratio of A+B+C₁ reserves to production is to be 25-30 to 1 at the end of the period (the Soviet norm¹⁶), about 15 trillion cubic meters of gas reserves would have to be developed in the interim.

10. Neporozhny, *op. cit.*, p. 17.

11. The Urals area is a net importer of coal and gas but a net exporter of oil.

12. A. Probst, *Voprosy Ekonomiki*, Jun 71 (JPRS 53747, 3 Aug 71, p. 41). Neporozhny, *op. cit.*, p. 17.

13. Neporozhny, *op. cit.*, p. 13.

14. Yu. Bokserman, *Neftyanik*, Jan 75 (JPRS 64264, p. 6).

15. Yu. A. Sokolovskiy, *Ekonomicheskiye problemy geologorazvedochnykh rabot*, Novosibirsk, 1974, p. 17-18.

16. *Metodicheskiye ukazaniya k razrabotke gosudarstvennykh planov razvitiya narodnogo khozyaystva SSSR* (JPRS 64294-2, 11 Mar 75, p. 489.)

18. Most of the increased output of natural gas through 1990 will come from West Siberia (see the map). Production in 1975 is scheduled to be only about 35 billion cubic meters. However, potential reserves of natural gas in West Siberia are estimated at 45 trillion cubic meters, of which 14 trillion were in categories A+B+C₁ as of January 1974.¹⁷ A Western correspondent was informed in March 1975 that 180 billion cubic meters are to be produced in 1980 and 500 billion cubic meters in 1990,¹⁸ although a West Siberian official stated in July 1975 that output in 1980 would be triple that in 1975, or only about 100 billion cubic meters.¹⁹ A factor limiting growth of output is the lack of pipeline capacity to deliver the gas to the Urals and to the European part of the country.²⁰

19. The remainder of the increase in output through 1990 will come mainly from Central Asia and Kazakhstan, where potential reserves are estimated at about 15 trillion cubic meters.²¹ Explored reserves in categories A+B+C₁ were reported to be 3.3 trillion cubic meters as of January 1974, and Central Asian and Kazakh output totaled about 80 billion cubic meters in 1974. Output in the European part of the USSR and the Urals probably will not increase much beyond the 1974 level of about 150 billion cubic meters. Increased output from the Orenburg gasfield in the Urals is likely to be largely offset by declines in other parts of the region. Although the Soviet Far East is believed to have great potential, natural gas output in this region in 1990 probably is projected at only about 30 billion cubic meters. Potential reserves, located largely in Yakutsk ASSR, are estimated to be about 25 trillion cubic meters.²² But A+B+C₁ reserves as of January 1974 were only about 700 billion cubic meters – of which about 400 billion were in Yakutsk ASSR – and current output is small.²³ Yakutsk gas is earmarked for use in the eastern regions of the USSR and for export, primarily to Japan and possibly to the United States.

Oil

20. Data supplied by Mel'nikov and Melent'yev suggest an increase in crude oil production from 459 million tons (656 million tons of SCE) in 1974 to about

17. *Geologiya nefi i gaza*, May 71, p. 10-13. Bokserman, *op. cit.*

18. *Baltimore Sun*, 23 Mar 74, p. K-7.

19. Foreign Broadcast Information Service, *Daily Report, Soviet Union*, 10 Jul 75, p. R-2.

20. N.V. Mel'nikov, *Fuel and Energy Resources and Distribution of Productive Forces of the USSR*, Preprints of Papers Presented at the Ninth World Energy Conference, Detroit, Sep 74, vol. 1, no. 1.2-23, p. 9-10.

21. N.V. Mel'nikov (ed.) *Energeticheskiye resursy SSSR, Toplivno-energeticheskiye resursy*, Moscow, 1968, p. 412.

22. *Geologiya nefi i gaza*, 1 Jan 75, p. 75.

23. Bokserman, *op. cit.*

750 to 800 million tons (1,073 to 1,144 million tons of SCE) in 1990. Shashin has indicated that the 1980 target is about 600 million tons (860 million tons of SCE).²⁴ Under this scenario, the growth of oil production would slow down from about 8% per year in 1960-75 to about 3% per year in 1976-90. In the oil industry, the availability of reserves is a more acute problem than in the gas industry. Soviet geologists apparently estimate total reserves at 175 billion tons. Explored reserves (categories A+B+C₁), however, probably total only about 20 billion tons, of which about 50% would be considered recoverable.²⁵ To expand output through 1990 in accordance with the projections shown in Table 2 would consume about 10 billion tons of recoverable reserves, or 20 billion tons of A+B+C₁ reserves. Maintenance of the estimated 1975 ratio of reserves to production (roughly 40 to 1) would require developing a total of about 30 billion tons of explored reserves (A+B+C₁) during 1976-90.²⁶

21. West Siberia now provides the bulk of annual increases in oil production in the USSR. This region reportedly contains 44% of the country's potential oil reserves²⁷ – or 75 to 80 billion tons, if total Soviet reserves are 175 billion tons, as indicated above. A Western correspondent was informed in April 1975 that reserves were about 10 billion tons (presumably explored reserves in categories A+B+C₁), a figure that is consistent with other Soviet claims.²⁸ In 1975, West Siberia is scheduled to produce 146-147 million tons, or 30% of total Soviet output. A 1969 government decree called for 230 to 260 million tons in 1980, but a figure of 300 million tons for 1980 has subsequently been given by some Soviet sources.²⁹

24. *Asahi Evening News*, 29 May 74, p. 1.

25. Data on oil reserves are classified as state secrets in the USSR, but Mel'nikov gave an estimate of 250 billion tons of SCE for combustible reserves of fuel other than coal, natural gas, peat, and shale, which presumably refers to crude oil. (N.V. Mel'nikov, *Energeticheskiye resursy SSSR*, op. cit., p. 37.) The estimate of 20 billion tons of explored reserves was derived from fragmentary data – on both national and individual regions and fields – published in Soviet books, periodicals, and newspapers. It is not clear whether the data refer to economically exploitable reserves, as seems to be true in the case of data on reserves of natural gas.

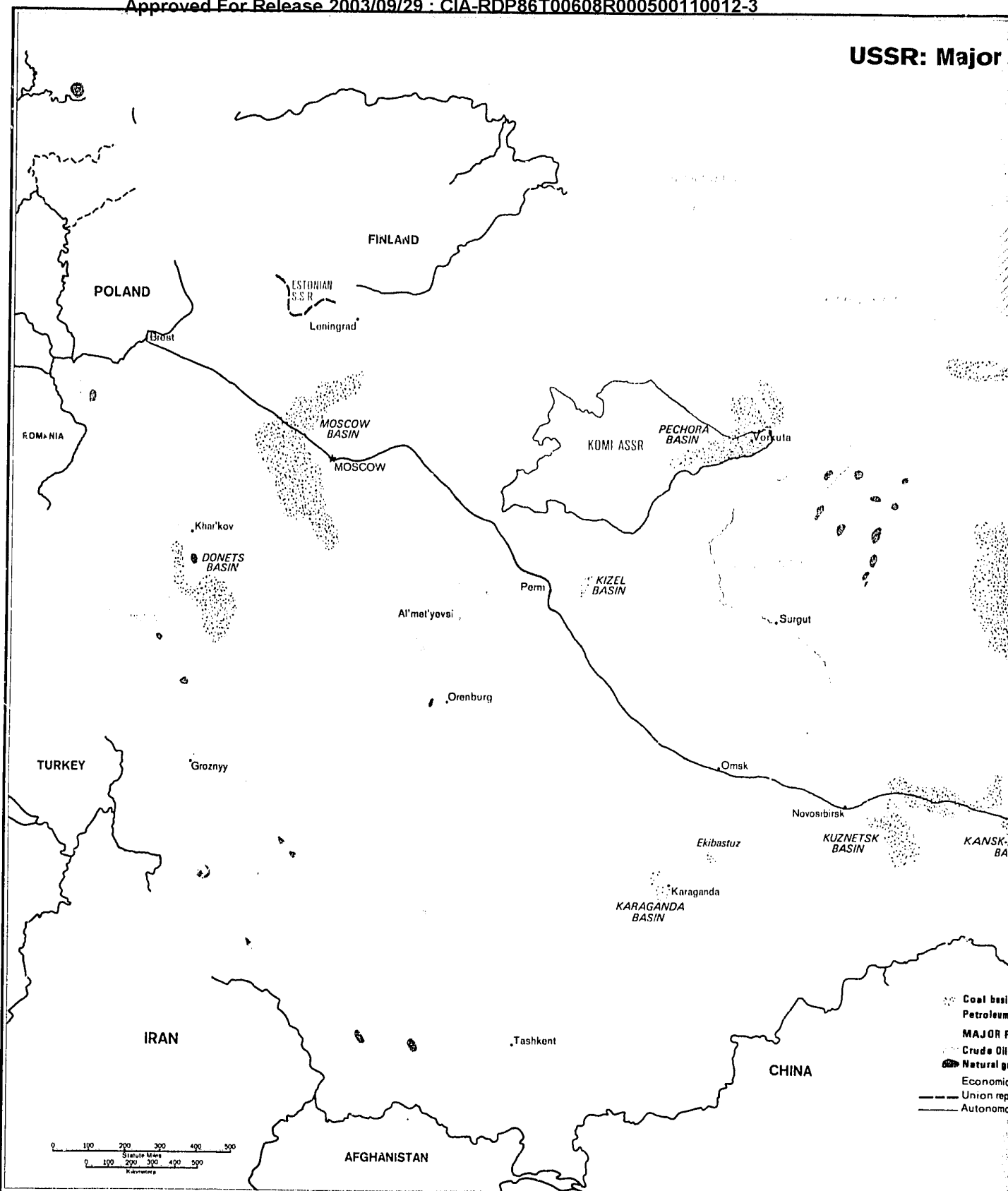
26. The Soviet norm for A+B+C₁ reserves is 35 to 40 times annual output. (*Metodicheskiye ukazaniya k razrabotke gosudarstvennykh planov razvitiya narodnogo khozyaystva SSSR* – JPRS 64294-2, 11 Mar 75, p. 489). Of the total A+B+C₁ reserves, approximately 40% should be in the C₁ or "probable" category. (N.P. Lebedinski (ed.), "Metodicheskiye ukazaniya k sotsovnleniyu gosudarstvennogo plana razvitiya narodnogo khozyaystva SSSR," *Ekonomika*, Moscow, 1969 – JPRS 49344, 3 Dec 69, p. 340.) Of the A+B (roughly equivalent to total "proved" reserves in place), perhaps 50% are recoverable. Hence, a ratio of 35 to 40:1 for total A+B+C₁ reserves would be equivalent to a norm for proved recoverable reserves of about 10 to 12 times annual output.

27. Foreign Broadcast Information Service, *Daily Report, Soviet Union*, 12 Apr 74, p. S-1.

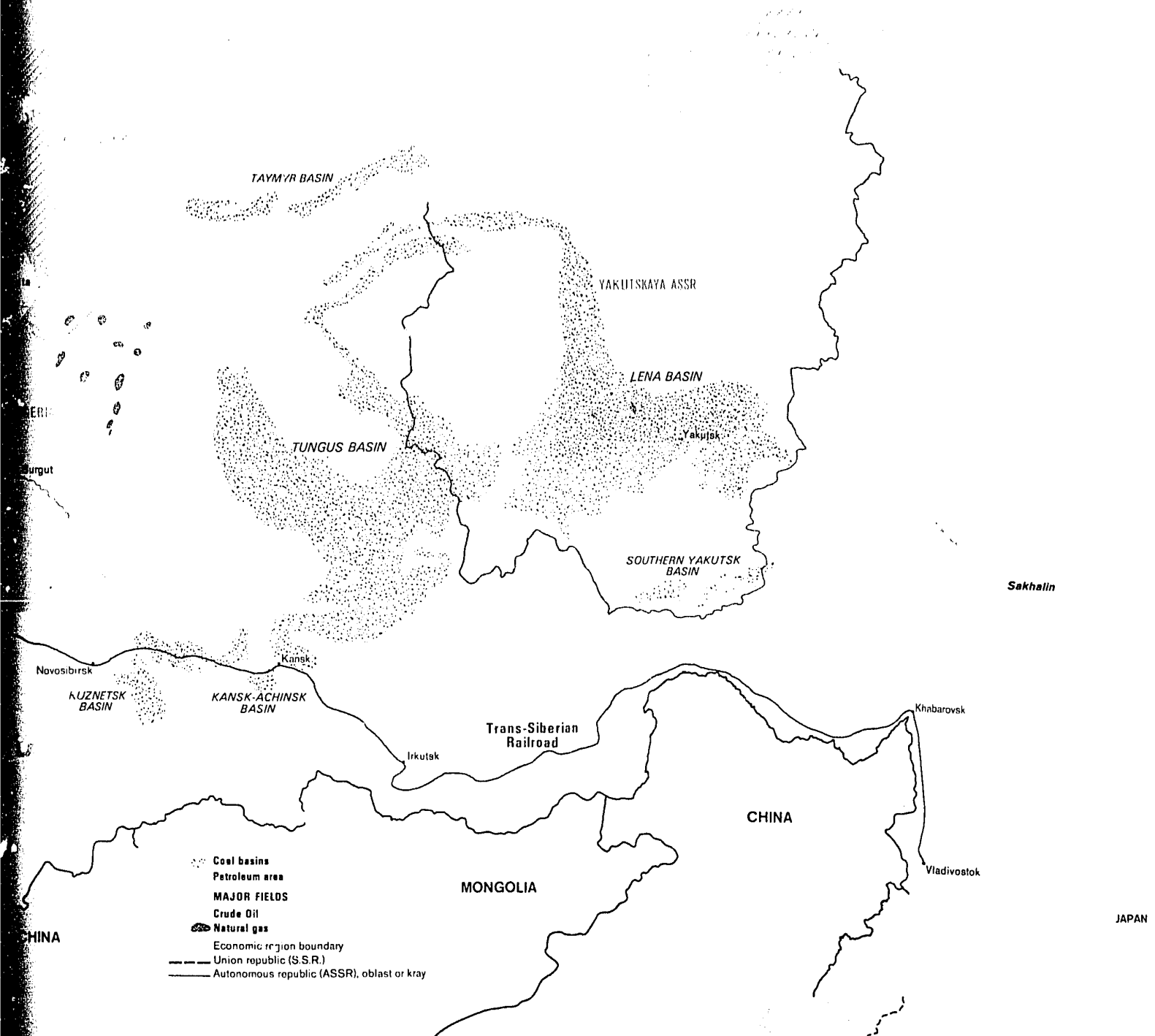
28. *Baltimore Sun*, 6 Apr 75, p. K-3.

29. Neftyanik, Dec 74 (JPRS 64142, 21 Feb 75, p. 14-15). Shashin, op. cit. Ye. Dvornikov, *Soviet Life*, Jan 74, p. 32. Foreign Broadcast Information Service, *Daily Report, Soviet Union*, 10 Jul 75, p. R-3.

USSR: Major



USSR: Major Soviet Petroleum and Coal Deposits



22. West Siberian output in 1990 is expected to be about 500 million tons, two-thirds of total Soviet output.³⁰ This production level will require the development of large reserves, particularly in the northern part of the region where more than half the potential reserves are believed to be located but where no major finds have as yet been reported.³¹ Although geologists hope to locate oil below known gas deposits, only gas condensate has been produced so far from deep drilling. If major discoveries are not made in the northern area, Moscow will have to rely primarily on the discovery of new reserves in East Siberia and in offshore areas.

23. In the European USSR, the Soviets intend to expand output in the Komi ASSR and to slow the decline in output from the older producing regions -- the Urals-Volga and Caucasus. They hope to increase the recovery rate from producing wells in the older producing regions by secondary and tertiary methods, using Western technology in some cases. Central Asia and Kazakhstan probably are expected to make only a relatively small contribution -- perhaps 30 million tons -- to the increase in oil output through 1990.

Coal

24. As production of oil and gas accelerated after 1960, the growth of coal production slowed. The share of coal in total fuel production declined from about 54% in 1960 to about 30% in 1975, but -- as indicated above -- the substitution of oil and gas for coal is expected to come to a halt after 1980. Output in 1990 is forecast at about 1.2 to 1.4 billion tons (800 to 940 million tons of SCE) according to the information supplied by Mel'nikov, Melent'yev, and other Soviet sources.³² The 1980 target is 810-820 million tons (about 560 million tons of SCE) according to a 1971 statement by the Minister of the Coal Industry.³³ In 1974, output totaled 685 million tons (479 million tons of SCE). The forecast for 1990 requires an increase in the rate of growth of coal production from 2% in 1961-75 to about 4% in 1976-90.

25. The decision to maintain coal's share of total fuel production stems from the fact that coal is far more plentiful than oil or gas. Total Soviet coal reserves are an estimated 8.7 trillion tons (6.2 trillion tons of SCE), of which 2.2 trillion tons are considered to be economically exploitable under present conditions.³⁴

30. Shashin, *op. cit.* Dvornikov, *op. cit.* Mel'nikov, *op. cit.* (20, above).

31. *Pravda*, 19 Feb 75, p. 3.

32. *Coal Age*, Dec 74, p. 40.

33. *Ugol'*, Jun 71, p. 5.

34. Mel'nikov, *op. cit.* (25, above).

Although explored coal reserves are only a small fraction of estimated reserves, they nevertheless are extremely large in relation to projected output. The USSR claimed coal reserves in categories A+B+C₁, amounting to 452 billion tons as of January 1970. Of this total, 276 billion tons were considered to be economically exploitable. Of the economically exploitable reserves, one-half, or about 140 billion tons, were considered to be recoverable.³⁵ Interpolation between the projections in Table 2 yields roughly 15 billion tons of coal produced in 1975-90 – only about one-tenth of the reserves already in the working inventory. Nevertheless, the situation is not as rosy as it appears, particularly in the short run. Mel'nikov, for example, says that:

...in spite of the availability of huge total geological reserves, the scale of possible exploitation of coal reserves, especially in the next decade, is still limited by insufficient exploration of a series of basins and deposits.³⁶

26. Coal extraction costs vary widely within the USSR (see Table 3). The cost of producing coal by surface mining operations at Ekibastuz in Kazakhstan, for example, is only about 15% of the cost of coal produced in underground mines in the Kizel Basin in the Urals. Even after adding the cost of transporting Ekibastuz coal the 1,000 kilometers to the Urals (4.23 rubles, as shown in Table 4), the delivered cost of Ekibastuz coal is still only about 37% of the cost of Kizel coal. Because of these cost differentials, most of the expansion in coal production during 1976-90 will be accounted for by surface mining at the Kansk-Achinsk, Kuznetsk, and Ekibastuz Basins. The data in Table 3 and Table 4 also show that the cost of Siberian and Kazakh coal obtained from surface mining compares favorably with the cost of Siberian oil and gas. Another factor in favor of maintaining the share of coal in Soviet fuel production is that most of the increase in coal production will occur in the southern portion of West and East Siberia. Infrastructure costs will be lower in these areas than in the less developed northern areas of West Siberia, where the major expansion in oil and gas production is to occur.

27. The Kansk-Achinsk brown coal deposits are a major case in point. They extend for several hundred miles along both sides of the Trans-Siberian Railroad in West and East Siberia. In 1966, they contained an estimated 68 billion tons of economically exploitable coal (categories A+B+C₁). In 1990, they are expected to provide 350 million tons of coal (175 million tons of SCE), or two-fifths of

35. Akademiya Nauk SSSR i Ministerstvo Geologii SSSR, *Geologiya ugol'nykh mestorozhdeniy*, vol. 2, Moscow, 1971, p. 299.

36. N.V. Mel'nikov, *Plannoye khozyaystvo*, Feb 75, p. 11.

Table 3

USSR: Estimated Cost of Production of Various Types of Fuel¹

Rubles per Metric Ton of Standard Coal Equivalent		
Type of Fuel and Location	1971 ²	1975 ³
Coal, open-pit, Kansk-Achinsk (West and East Siberia)	1.8	2.4
Coal, open-pit, Ekibastuz (Kazakhstan)	2.7	2.5
Natural gas, Tyumen Oblast (West Siberia)	2.2	6.6
Natural gas, Central Asia	5.4	7.0
Crude oil, Tyumen Oblast	6.2	6.7
Coal, open-pit, Kuznetsk (West Siberia)	6.6	8.6
Coal, open-pit, Minusinsk (East Siberia)	7.7	
Crude oil, Mangyshlak (Kazakhstan)	8.3	
Coal, underground, Kuznetsk (West Siberia)	11.5	
Oil shale, Estonia	11.6	
Peat	11.6	
Coal, underground, Karaganda (Kazakhstan)	12.3	12.8
Coal, underground, Pechora (Komi ASSR)	13.1	
Coal, underground, Donets (Ukraine SSR)	15.3	17.0
Coal, underground, Kizel Basin (Urals)	18.5	
Coal, underground, Kirgiz SSR (Central Asia)	21.1	
Coal, underground, Moscow Basin	23.0	24.1
Coal, underground, Lenger (Kazakhstan)	23.4	

1. Including capital charge.

2. A. Probst, *Voprosy ekonomiki*, Jun 71 (JPRS 53747, 3 Aug 71, p. 37).3. Ya. Mazover, *Planovoye khozyaystvo*, Jun 75, p. 66.

Table 4

USSR: Cost of Shipping Various Types of Fuel
a Distance of 1,000 Kilometers¹

Rubles per Metric Tons of Standard Coal Equivalent		
Type of Fuel	Means of Shipping	Cost ²
Crude oil	1,020-mm pipeline	0.44
Natural gas	1,020-mm pipeline	2.63
Coal, Kuznets	Rail	3.23
Coal, Ekibastuz	Rail	4.23
Coal, Kansk-Achinsk	Rail	5.37

1. Probst, *op. cit.*, p. 38.

2. Including capital charge.

the countrywide increase in annual output over the level of 1975.³⁷ By comparison Kansk-Achinsk annual output is only 25 million tons now. Kansk-Achinsk coal cannot be shipped in its raw form from Siberia to the energy-consuming centers in the European USSR because of its relatively low heating value and poor physical characteristics. Consequently, the coal is to be consumed in electric power stations to be built in the area, processed into semi-coke for long-distance transport by rail, or perhaps (eventually) delivered by pipeline in the form of slurry. Part of the electricity generated will be used locally; the rest is to be transmitted to the European part of the USSR via very high voltage direct current transmission lines when this technology is perfected.

28. The Kuznetsk coalbasin in West Siberia – the other major source of new coal – produced about 135 million tons in 1974 (120 million tons of SCE) and contained economically exploitable reserves (categories A+B+C₁) of 53 billion tons. The 1990 output target is 350 million tons.³⁸ The Ekibastuz deposit in Kazakhstan has economically exploitable reserves in categories A+B+C₁ of at least 7 billion tons; output (all by surface mining operations) is to increase from 45 million tons (28 million tons of SCE) in 1975 to about 120 million tons in 1990.³⁹ Donets output, which will amount to about 215 million tons in 1975, is not expected to increase, because of relatively high production costs (see Table 3). Nonetheless, the Donets Basin contains an estimated 39 billion tons of reserves in categories A+B+C₁.

Hydroelectric Power

29. According to Mel'nikov, hydroelectric power will account for 1% of the total energy supply in 1990. This equals about 285 billion kilowatt-hours, or one-quarter of the USSR's potential output of economically exploitable hydroelectric power.⁴⁰ A large part of new hydroelectric power capacity will be

37. Foreign Broadcast Information Service, *Daily Report, Soviet Union*, 14 May 74, p. S-2. The 1990 target was originally 182 million tons of coal, according to a detailed forecast of surface-mined coal published by Mel'nikov in 1971 (N.V. Mel'nikov, *Ugol'*, Aug 71 – JPRS 54148, 28 Sep 71, p. 14). The target was apparently raised when the revised forecast for 1990 was prepared in 1972 or 1973.

38. The figure of 350 million tons was mentioned by Mel'nikov in 1973 and appears to be about 150 million tons above earlier targets. (BBC, *Summary of World Broadcasts, USSR, Weekly Economic Report*, 13 Apr 73, p. A-10.) However, in 1974 a technician at the Kuzbass Polytechnic Institute gave an "estimate" for 1990 of only 200 to 220 million tons (K.M. Zvyagintsev, *Izvestiya Sibirskogo Otdeleniya Akademii Nauk SSSR*, Jan 74 – JPRS 62909, 9 Sep 74, p. 4).

39. BBC, *Summary of World Broadcasts, USSR, Economic Report*, 22 Nov 74, p. A-11. N.V. Mel'nikov, *Ugol'*, August 1971, *op. cit.*

40. A.N. Vosnesenskiy (ed), *Energeticheskiye resursy SSSR, Gidroenergeticheskiye resursy*, Moscow, 1967, p. 157. Thirty-five million tons of standard coal converted at a rate of 123 grams per kilowatt-hour would be equal to 285 billion kilowatt-hours. Output of hydroelectric power in 1975 will be about 140 billion kilowatt-hours.

built in East Siberia, where potential output is an estimated 350 billion kilowatt-hours per year or 43 million tons of SCE. The electric power will serve expanded industrial production in East Siberia, particularly energy-intensive production such as aluminum.

Nuclear Electric Power

30. Melent'yev said in 1974 that Soviet technicians forecast nuclear electric power production in 1990 at 500 to 650 billion kilowatt-hours, or 150 to 200 million tons of SCE. This target probably will not be reached in 1990. Likewise, the 1980-82 target of 32 million kilowatts of capacity (about 200 billion kilowatt-hours of annual production) announced at the 24th Communist Party Congress in April 1971 seems overly optimistic.⁴¹ A June 1975 Moscow radio broadcast indicated that the Soviets may now be aiming for 30 to 37 million kilowatts of capacity by 1985.⁴² Most of the new capacity will be installed in the European part of the USSR.

Imports

31. The future contribution of imports to the Soviet energy supply is rarely mentioned in the Soviet press, but the forecasts probably assume a substantial increase over the 1973 level - 44 million tons of SCE. Mel'nikov has estimated that imports together with production of peat, shale, and fuelwood will account for 5% of the energy supply in 1990. When related to Styrikovich's 3-1/2 billion ton requirement in 1990, this figure equals about 170 million tons of SCE. The combined production of peat, shale, and fuelwood probably is to rise to about 70 million tons of SCE by 1990, leaving about 100 million tons of SCE for imports.

32. Soviet sources afford few clues to the expected composition of fuel imports in 1990. Soviet imports of coal, all from Poland for use in the western regions of the USSR, increased from about 4 million tons SCE in 1960 to 9 million tons in 1974,⁴³ and a Polish official has indicated that deliveries are to increase in partial payment for increasing deliveries of Soviet oil and gas.⁴⁴ Soviet energy forecasts probably assume coal imports of something like 20 million tons SCE in 1990.

41. *Pravda*, 7 Apr 71, p. 4.

42. Foreign Broadcast Information Service, *Daily Report, Soviet Union*, 6 Jun 75, p. U-3.

43. *Vneshnyaya trgovlya SSSR za 1974 god*, Moscow, 1975, p. 44.

44. Foreign Broadcast Information Service, *Daily Report, Soviet Union*, 11 May 71, p. E-3.

33. Natural gas from Iran and Afghanistan augments Soviet supplies in the Transcaucasus and Central Asia. In 1974, Iranian deliveries totaled 11 million tons SCE and those from Afghanistan, 3 million tons. During the remainder of the 1970s, annual gas deliveries will increase to about 12 million tons from Iran and 4 to 5 million tons from Afghanistan. After 1981, the Soviets will receive an additional 2 to 4 million tons SCE of Iranian gas as a transit fee for Iranian gas pipelined through the USSR to West Germany. Moreover, the possibility has been discussed of building a second line from Iran to the USSR to double Iranian gas deliveries to the Transcaucasus, where domestic production is expected to decline.⁴⁵ Soviet forecasters may therefore be counting on natural gas imports of about 30 million tons SCE in 1990.

34. Subtracting coal and natural gas imports from the total import figure of 100 million tons SCE yields a residual for imports of oil in 1990 of some 50 million tons SCE (700,000 b/d), an amount that appears plausible. Crude oil has been, and probably will continue to be, procured under barter agreements with Middle Eastern countries for re-export on Soviet account to Eastern Europe and other Communist countries. Such crude oil imports increased rapidly from 5 million tons SCE in 1970 to 19 million tons in 1973. In 1974, however, they dropped to 6 million tons of SCE. This curtailment was made possible, in part, by a reduction of 7 million tons of SCE in Soviet sales of oil to non-Communist countries.

35. The derived forecasts of Soviet fuel imports in 1990 are compatible with estimates of future import requirements of the USSR and Eastern Europe published in a Soviet journal in 1971. Energy specialists were said to have estimated that in 15 to 20 years the "socialist countries of Europe" may need annually, from the less developed countries, 60 to 90 million tons of oil (86 to 129 million tons SCE) and 40 to 50 billion cubic meters of natural gas (48 to 60 million tons SCE).⁴⁶

Fuel for Electric Powerplants

36. A key aspect of energy policy in the USSR – as elsewhere – is the choice of fuel for electric power production. Powerplants typically account for a large share of the total energy consumption, and almost all fuels can be used to some extent. In 1973, coal and other solid fuels provided 46% of the energy required in the USSR for centralized production of heat and electric power (see Table 5).

45. *The Reuter East-West Trade News*, 15 Oct 70, p. 3.

46. L. Zevin, *Planovoye khozyaystvo*, Jul 71, p. 24.

Table 5

USSR: Estimated Energy Requirements, by Type

Million Metric Tons of Standard Coal Equivalent						
	Energy Types					
	Total	Oil	Natural Gas	Solid Fuels	Hydro and Nuclear	Other
1973						
Total	1,520	635	296	534	19	36
Losses, non-energy uses, and additions to stocks	110	74	22	14	....	....
Exports	204	171	8	25	....	....
Mobile and stationary engines	219	204	5	10	....	....
Industrial furnaces and related uses	273	48	84	125	....	16
Small heating devices	203	20	59	124	....	....
Generation of electricity, steam, and hot water ¹	511	118	118	236	19	20
1990						
Total	3,500	1,150	1,130	960	210	50
Losses, non-energy uses, and additions to stocks	300	140	130	30	....	....
Exports	540	330	170	40	....	....
Mobile and stationary engines	455	430	25	....	....	....
Industrial furnaces and related uses	385	60	110	190	....	25
Small heating devices	175	15	115	45	....	....
Generation of electricity, steam, and hot water ¹	1,645	175	580	655	210	25

1. Including steam and hot water supplied from thermal powerplants and large boilers only.

The forecasts of energy requirements and supply imply that solid fuels will still account for about 40% of the energy used for this purpose in 1990.

37. Continued heavy reliance on coal for electric power production is based on plentiful reserves of comparatively low-cost coal in the eastern regions of the USSR, the rising cost of other fuels, and uncertainty about their availability. In 1974, Melent'yev made it clear that because of doubts about the future development of oil and gas reserves, the technicians responsible for the final version of the

1990 forecast of energy supply had lowered the targets for oil and gas production, raised the target for coal production, and recommended that more of the large thermal powerplants to be built in the European part of the USSR and the Urals be designed to burn coal.⁴⁷

38. The sharp rise in world oil prices since October 1973 undoubtedly increased incentive to limit the consumption of oil and gas in thermal powerplants. In early 1974, Styrikovich noted that the price changes had increased the economic effectiveness of Soviet exports of oil. He urged more rapid development of fuels production coupled with substitution of coal for oil in low-priority uses, first of all in large thermal power stations.⁴⁸

39. In November 1974 the Chairman of the USSR State Committee on Science and Technology, V.A. Kirillin, stated, in a speech before the USSR Academy of Sciences, that greater use of coal must be made in large thermal powerplants. He stressed the point that Soviet coal reserves were many times greater than those of oil and gas.⁴⁹ He made no reference to higher world oil prices and did not suggest that Soviet authorities were considering conversion, or reconversion, to coal of existing large thermal powerplants fired by oil or gas.⁵⁰ Kirillin did in fact say that in the interest of clear air, most smaller thermal powerplants, which usually distribute steam and hot water as well as electricity in or near urban areas, would burn gas or oil. Still, with the increased emphasis on coal, the share of oil in energy consumption for generation of electricity and steam is scheduled to drop from 23% in 1973 to about 11% in 1990 (see Table 5).

40. The structure of fuel prices does not reflect the new view of the energy balance, however. For example, adjustments may have to be made to help limit the use of residual fuel oil (mazut) in powerplants and boilers. Before 1967, the delivered price of mazut, on an SCE basis, was more than 40% above the price

47. Melent'yev, *op. cit.*, p. 15. The magnitude of the recommended shift toward greater use of coal appears to have been about 100 to 200 million tons of SCE per year by 1990. As noted above, the target for the Kansk-Achinsk Basin seems to have been raised by 168 million tons (85 million tons of SCE) and the target for the Kuznetsk Basin may have been increased by as much as 150 million tons (135 million tons of SCE). The countrywide forecast for coal production in 1990 appears to have been increased from 1,100 million tons (740 million tons of SCE) to 1,300 million tons (870 million tons of SCE), or by 130 million tons of SCE. It was also indicated that the recommended substitution of coal for oil and gas in large thermal powerplants to be built in 1976-80 would amount to 35 to 50 million tons of SCE per year by 1980. By extension, the figure might be 150 million tons of SCE by 1990.

48. M.A. Styrikovich, *Izvestiya Akademii Nauk SSSR, Energetika i transport*, May-Jun 74, p. 8.

49. Foreign Broadcast Information Service, *Daily Report, Soviet Union*, 4 Dec 74, p. S-2.

50. These plants, most of which are located in the European part of the USSR or the Urals, will consume roughly 100 million tons of SCE in 1975.

of coal and natural gas, partly to restrict its use.⁵¹ In 1967 the price of coal was increased by about 50% to an average delivered price of 15 rubles per ton of SCE. The price of natural gas was also raised to this level. But, the price of mazut was not increased enough to maintain the previous differential, apparently because the price of diesel fuel was not changed. The mazut price was therefore lifted by only 10%, to an average delivered price of 17 rubles per ton of SCE.

Western Technology and Equipment

41. The USSR buys substantial amounts of material, equipment, and related technology for its energy sector from Western countries, and Soviet policy probably calls for continued, if not greater, reliance on the West in the future. The most important imports to date have been large-diameter (40- to 56-inch) pipe for transmission of oil and gas; in 1974, pipe imports totaled 1.3 million tons and were valued at US \$402 million. Other purchases included smaller sizes of pipe for oilfield operations (\$95 million), equipment for oil and gas exploration and extraction (\$9 million), and oil refining equipment (\$12 million).

42. Imports are being financed, in part, by long-term credits that provide for repayment in fuels or other commodities. Contracts signed in 1970, 1972, and 1974 between the USSR and West Germany, for example, provide for Soviet imports of 3.7 million tons of large-diameter pipe and related pipeline equipment, financed by \$1.6 billion worth of credits.⁵² The credits in turn will be repaid by deliveries of natural gas, which are expected to reach 10 billion cubic meters per year by 1980. An agreement between the USSR and Japan for exploitation of Yakutsk coal involves Japanese credits totaling \$450 million, mainly for Soviet purchase of coal mining and processing equipment. Under the Soviet-Japanese agreement for exploration for oil off Sakhalin Island, Japan will lease drilling rigs to the USSR while furnishing a \$100 million credit.

43. The USSR has also shown a strong interest in stepping up its lagging nuclear electric power program with the assistance of Western countries. For more than two years the Soviets have been negotiating with West Germany to buy up to four 1,300-megawatt (MW) nuclear power stations, to be paid for by electric power sent back to Germany.⁵³ Negotiations are proceeding with a French firm for the purchase of six 900-MW nuclear reactors.⁵⁴ The Soviets also requested

51. V.K. Shkatov, *Optovyye tseny na produktsiyu tyazheloy promyshlennosti* (JPRS 63660, 13 Dec 74, p. 50).

52. *Pravda*, 30 Oct 74, p. 4.

53. *New York Times*, 15 Jan 75, p. 27.

54. *Nucleonics Week*, 6 Mar 75, p. 2.

that Japan supply the equipment for a 4,000-MW nuclear powerplant on Sakhalin Island and have submitted proposals to the United Kingdom for nuclear cooperation, including possible Soviet purchase of British nuclear equipment.⁵⁵

44. Although Western assistance in Soviet energy development is already important, the USSR is interested in tapping Western technology on a much larger scale, judging from a Soviet paper prepared for a November 1974 seminar on the potential for economic cooperation between East and West.⁵⁶ The paper suggests that West European countries consider participating in the development of four coal basins in the northern and eastern USSR. Only one of these basins, Pechora, is currently being mined to a significant degree. The paper suggests that the Pechora coal be hydrogenated and gasified and that the synthetic fuel thus obtained be exported to Western Europe through northern ports. The paper also broached the possibility of processing coal in the same manner from the Tungus, Taymyr, and Lena Basins, which contain an estimated 5 trillion tons of hard and brown coal. (According to earlier indications, the USSR did not envision large-scale exploitation of these coal fields until some time after the year 2000.) The paper also suggested that West European countries help to locate and develop oil and gas reserves believed to be present in East Siberia and the Soviet Far East and offshore from the Arctic coast in the Barents and Kara Seas.

Assistance from Eastern Europe

45. Soviet policy clearly calls for increasing shipments of fuel to East European countries. In return, the USSR expects these countries to provide some of the capital required to develop fuel resources in the USSR. One Soviet writer claims that the capital investment required to expand exports of oil and gas from the USSR to Eastern Europe in 1960-74 amounted to 7.5 billion rubles, of which 1.2 billion rubles resulted from credits supplied by Eastern Europe.⁵⁷ Although information on the future participation of Eastern Europe in development of Soviet fuel resources is incomplete, these countries have agreed to build a pipeline costing \$2 to \$4 billion from the Orenburg gasfield in the Urals to the western border of the USSR, in return for deliveries of natural gas. Also, Poland and Czechoslovakia have contracted to build oil pipelines in the USSR valued at several hundred million dollars, in exchange for deliveries of oil over and above amounts stipulated in bilateral agreements. A substantial share of the equipment and materials for these projects probably will be purchased from non-Communist countries.

55. *Applied Atomic*, 2 Jul 74, p. 3. *Financial Times*, 7 Nov 74, p. 9.

56. N.N. Nekrasov, *Energetics and Natural Resources*, Moscow, 1974.

57. A. Lalayantz, *Planovoye khozyaystvo*, Apr 75, p. 29.

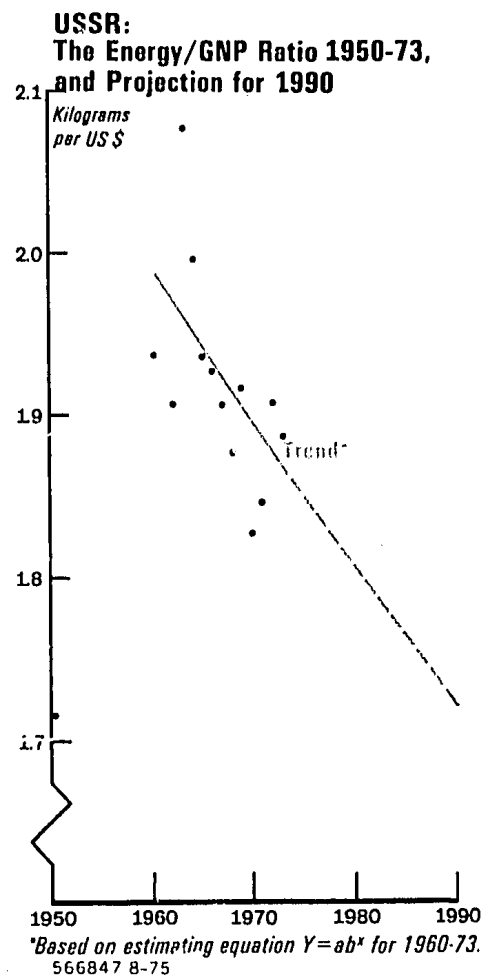
46. The Soviet Union, besides constructing nuclear powerplants on its own territory, is helping to build such plants in Eastern Europe. In order to meet the demand for basic and auxiliary equipment for reactors and other installations, the CEMA organization Interatomenergo was formed. Each member country has been given the responsibility for producing specific items of equipment. In addition, the USSR has signed agreements with Czechoslovakia, Hungary, Poland, and Yugoslavia under which these countries will supply components for nuclear powerplants in the USSR.

APPENDIX

ENERGY CONSUMPTION AND GROSS NATIONAL PRODUCT

Energy consumption in the USSR has been growing at roughly the same rate as gross national product¹ (see the Appendix table). Energy consumption per dollar of GNP increased from 1.72 kilograms of SCE in 1950 to 1.94 in 1960; the year-to-year movement of the ratio during this period is unknown because of a lack of data on energy consumption. During 1960-73, the ratio of energy to GNP changed erratically, largely reflecting the substantial impact on GNP of poor harvests (1963 and 1972).

A detailed study of the many factors that influence the energy/GNP ratio has not been made. A trend line fitted to the 1960-73 data yields an annual decline in the ratio of 0.5%, but this is a weak base for long-term projections, and different interpretations of historical trends can be defended (see the chart). Fragmentary information in the Soviet press indicates that Soviet technicians expect the decline in energy consumption per ruble of national income² to slow from 2.0% per year in 1961-73 to perhaps 1.3% per year in the period through 1990.³ On the other hand, one Western expert on the Soviet economy, Professor Robert Campbell, argues that the energy/GNP ratio will rise in the future. Campbell believes that opportunities for economizing on energy are more limited than in the past and that other factors (for example, the growth in income-elastic household energy consumption such as private automobile transportation) will be more influential.⁴



1. In the United States, by way of comparison, the consumption of energy per (1973) dollar of GNP declined in an irregular pattern from 2.25 kilograms of SCE in 1950 to 2.11 kilograms in 1973. The downward trend in the United States began in the 1920s.

2. The Soviet definition of national income excludes services unrelated to material production.

3. N.V. Mel'nikov, *Vestnik Akademii Nauk SSSR*, Feb 74, p. 69. S. Fel'd, *Planovoye khozyaystvo*, Feb 69 (JPRS 47720, 26 Mar 69, p. 30).

4. Robert Campbell, *Exploitation of Siberia's Natural Resources*, NATO, Directorate of Economic Affairs, Brussels, 1974, p. 79.

USSR: Energy Consumption, Gross National Product, and the Energy/GNP Ratio

	Energy Consumption		Gross National Product		Energy/GNP Ratio	
	Million Metric Tons of Standard Coal Equivalent ¹	Percent Change from Preceding Year	Billion 1973 US \$ ²	Percent Change from Preceding Year	Kilograms per US \$	Percent Change from Preceding Year
1950	331		192		1.72	
1960	678	7.4 ³	350	6.2 ³	1.94	1.2 ³
1961	N.A.	N.A.	377	7.7	N.A.	N.A.
1962	757 ⁴	5.7 ⁵	396	5.0	1.91	-2.9 ⁵
1963	834 ⁴	10.2	401	1.3	2.08	8.9
1964	868 ⁴	4.1	435	8.5	2.00	-3.8
1965	898	3.5	464	6.7	1.94	....
1966	952	6.0	493	6.3	1.93	-0.5
1967	999	4.9	524	6.3	1.91	-1.0
1968	1,045	4.6	555	5.9	1.88	-1.6
1969	1,099	5.2	572	3.1	1.92	2.1
1970	1,119	1.8	613	7.2	1.83	-4.7
1971	1,180	5.5	639	4.2	1.85	1.1
1972	1,251	6.0	655	2.5	1.91	3.2
1973	1,314	5.0	698	6.4	1.88	-1.0
Average annual increase for 1961-73		5.2		5.5		

1. Coal with a heat value of 7,000 kilocalories per kilogram.

2. Estimated. Market prices, geometric mean US dollars.

3. Average annual increase for 1951-60.

4. Adjusted upward from published data, which did not include hydroelectric power for 1962 and 1963 and which did not include energy from certain other sources for all three years.

5. Average annual increase for 1961-62.

A reasonable forecast for 1990 might be that the energy/GNP ratio will fall within the range of 1.72 to 2.00 kilograms per dollar. If so, the forecast of energy consumption for 1990 of 2,950 million tons of SCE in Table 1 implies a GNP for 1990 of \$1,475 to \$1,715 billion (1973 dollars). This range of GNP represents, in turn, an annual GNP growth rate of 4.5% to 5.4% per year in 1974-90, a plausible enough projection.